

TITLE OF THE INVENTION

FLUOROALKYL-FUNCTIONAL ORGANOSILOXANE-CONTAINING
COMPOSITIONS BASED ON ALCOHOL, A PROCESS FOR
THEIR PREPARATION AND THEIR USE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to fluoroalkyl-functional organopolysiloxane-containing compositions based on alcohol, to a process for their preparation and to their use.

Description of the Background

Organosilanes of the formula $R'-Si(R'')_3$, where R' is a fluorinated organic radical and R'' is a chlorine or methoxy or ethoxy group, have diverse uses, for example, in the application of hydrophobically and oleophobically acting layers on surfaces. Such coatings and impregnations can be produced at the worksite, for example, by dipping, impregnating, spraying or rolling operations.

It is also known that oil- and water-repellent coatings on surfaces, usually glass surfaces, can be produced with fluoroalkylalkoxysilanes. The coatings can be used, for example, as a dirt-repellent treatment on plate glass. The processes described are based on sol-gel processes, very fine inorganic particles being produced and employed together with the fluoroalkylalkoxysilane. Application of such systems is technically demanding, and usually uses complex organic solvent mixtures and additives. Moreover, such systems comprise chlorine and furthermore only remain fit to use for a

relatively short period of time (European Laid-Open Application No. 0 658 525, European Laid-Open Application No. 0 629 673 and U.S. 5 424 130).

Since the processes employed are sol-gel process
5 embodiments, which are demanding both in their use and
economically, their commercial utilization has to date been
limited to niche areas. Furthermore, there are narrow time
limits with respect to processability and, therefore, the
subsequent efficacy of such fluoroalkylsilane containing
10 formulations on a substrate surface. These factors are an
impediment to broader use of the formulation in practice. In
addition, a partial to complete loss of adhesive action can be
experienced, and a slow phase separation up to laminar
deposition of a fluoroalkylsilane-containing phase can occur.

15 The complicated application processes and, also the use
of solvents such as fluorinated hydrocarbons or
fluorohydrocarbons, therefore, are disadvantages of such
processes (European Laid-Open Application No. 0 491 251,
European Laid-Open Application No. 0 493 747).

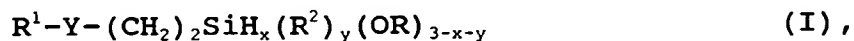
20 In the case of the known solvent-based systems, it must
be noted that although some systems are stable over the long
term in the non-hydrolyzed state, they are distinguished by an
efficacy limited to a maximum of a few days in the hydrolyzed
form because of the progressive polycondensation of the
25 silanol functions. When formulations are prepared in which
the content of silanol groups is continuously reduced in order
to reduce the undesired polycondensation, the extent of
chemical bonding by the silanol groups to a substrate surface

is furthermore reduced, this subsequently manifesting itself in unsatisfactory adhesion of the coating to the substrate surface. A need, therefore, continues to exist for an aqueous organosilane solution which is stable over prolonged periods of time and which provides coated substrates with both hydrophobic and oleophobic properties.

Summary of the Invention

Accordingly, one object of the present invention is to provide aqueous organosilane formulations which can be prepared in a simple and economical manner and which are essentially free of chlorine, and furthermore have adequate stability over relatively long periods of time, and which simultaneously impart hydrophobic and oleophobic properties on substrate surfaces by an impregnation process which is easy to carry out.

Briefly, this object and other objects of the present invention as hereinafter will become more readily apparent can be attained by an alcoholic fluoroalkyl-functional group containing organosiloxane based composition prepared by the controlled hydrolysis of at least one fluoroalkyl-functional group containing organosilane of formula I:

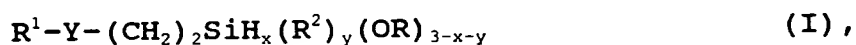


in which R^1 is a mono-, oligo- or perfluorinated alkyl group having 1-9 C atoms or a mono-, oligo- or perfluorinated aryl group, Y is a CH_2 , O or S group, R^2 and R are each independently a linear, branched or cyclic alkyl group having 1-8 C atoms or an aryl group and $x = 0, 1$ or 2 and $y = 0, 1$ or

2, where $(x+y) \leq 2$, at a temperature in the range of 0-120°C over a period of 0.5-24 hours and with thorough mixing in an alcoholic medium which, contains water, and a weak mono- or polybasic acid or a weak base or a weak mono- or polybasic acid and a weak base or an acid or basic salt, the water employed and the alkoxysilane employed being in a molar ratio of 2-500:1.

Detailed Description of the Preferred Embodiments

It has been found, surprisingly, that aqueous organosiloxane-containing compositions which contain Si-bonded fluoroalkyl functional groups are accessible in a simple and economical manner as chlorine-free, homogeneous, clear solutions which are stable for several months if at least one fluoroalkyl-functional group containing organosilane of formula I:

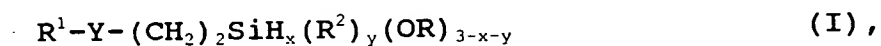


in which R^1 is a mono-, oligo- or perfluorinated alkyl group having 1-9 C atoms or a mono-, oligo- or perfluorinated aryl group, Y is a CH_2 , O or S group, R^2 and R are each independently a linear, branched or cyclic alkyl group having 1-8 C atoms or an aryl group and $x = 0, 1$ or 2 and $y = 0, 1$ or 2 , where $(x+y) \leq 2$, is hydrolyzed in a controlled manner, with thorough mixing, in an alcoholic medium which, in addition to water, comprises a weak mono- or polybasic acid or a weak base or a weak mono or polybasic acid and a weak base or an acid or basic salt, at a temperature in the range of 0-120°C and over a period of 0.5-24 hours, the water and the alkoxysilane of

formula I being employed in a molar ratio of 2-500:1. The compositions of the invention furthermore can be employed for simultaneous hydrophobization and oleophobization of substrate surfaces in a simple manner with an outstanding action.

5 Compositions of the invention preferably have a pH of 2-12, particularly preferably a pH of 3-10, and normally have a viscosity of less than 10,000 mPa·s. The content of alcohols in the compositions of the invention is preferably 40-99.999% by weight, based on the total composition, the composition
10 preferably comprising fluoroalkylfunctional organosiloxanes in amounts of 0.001-30% by weight, particularly preferably 0.01-5% by weight, and especially preferably 0.1-2% by weight, based on the composition.

Another aspect of the present invention relates to a
15 process for the preparation of a fluoroalkyl-functional organosiloxane containing composition, which comprises subjecting at least one fluoroalkyl-functional organosilane of formula I:



20 in which R^1 is a mono-, oligo- or perfluorinated alkyl group having 1-9 C atoms or a mono-, oligo- or perfluorinated aryl group, Y is a CH_2 , O or S group, R^2 and R are each independently a linear, branched or cyclic alkyl group having 1-8 C atoms or an aryl group and $x = 0, 1$ or 2 and $y = 0, 1$ or
25 2 , where $(x+y) \leq 2$, to controlled hydrolysis with thorough mixing, in an alcoholic medium which, in addition to water, comprises a weak mono- or polybasic acid or a weak base or a weak mono or polybasic acid and a weak base or an acid or

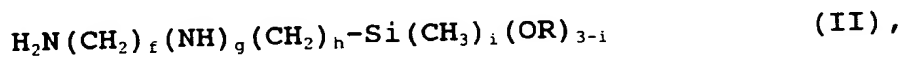
basic salt, at a temperature in the range of 0-120°C and over a period of 0.5-24 hours, preferably 1-12 hours, particularly preferably over a period of 2-6 hours, the water and the alkoxysilane being employed in a molar ratio of 2-500:1.

5 In the process of the invention, the fluoroalkyl-functional group containing organosilane of formula I is preferably metered into the reacting medium in portions with periodic interruptions. However, the metering operation can also be carried out continuously with periodic interruptions, 10 or the batchwise and continuous procedures for the metering can be combined with one another in a suitable manner.

The reaction is in general carried out at a temperature within the range of 0-120°C, preferably in a temperature range of 10-80°C, particularly preferably of 20-60°C. The reaction 15 medium is normally stirred.

In the process according to the invention, the pH of 2-12 in the reaction medium is suitably established by employing a weak mono- or polybasic acid or a weak base or a weak mono- or polybasic acid and a weak base or an acid or basic salt.

20 The weak base employed in the process of the invention is an organosilane of formula II:



in which $0 \leq f \leq 6$, $g=0$ if $f=0$ and $g=1$ if $f>1$, $0 \leq h \leq 6$, $0 \leq i \leq 1$ and R is a linear, branched or cyclic alkyl group having 1-8 C 25 atoms or an aryl group, or an alkylamine of formula III:



in which R^3 is a linear, branched or cyclic alkyl group having 1-8 C atoms or a linear, branched or cyclic aminoalkyl

group having 1-8 C atoms or an aryl group, $z = 1, 2$ or 3 and groups R^3 are identical or different.

Particularly preferred examples of the organosilane include aminopropyltriethoxysilane, aminopropyltrimethoxysilane, aminopropylmethyldiethoxysilane and aminopropylmethyldimethoxysilane. Of the trialkylamines, preferred are mono-, di- and trialkylamines, preferably C_{1-3} alkyl groups.

Weak acids such as formic acid, acetic acid, propionic acid or citric acid, can also be employed in the process of the invention. If weak acids and weak bases are employed simultaneously, it is not necessary to maintain an equimolar ratio between acid and base.

In the process of the invention, acid salts which can be employed include, for example, alkali metal hydrogen sulfate or dihydrogen phosphate or aluminum acetate, and basic salts which can be employed include, for example, magnesium hydroxide or alkali metal acetate or alkali metal bicarbonate or alkali metal carbonate.

The reaction medium of the present process is preferably the alcohol corresponding to the alkoxy group of the organosilane employed; methanol, n-propanol, i-propanol, n-butanol, i-butanol, t-butanol and/or 2-methoxyethanol. Ethanol is particularly employed.

Linear perfluoroalkylalkoxysilanes are preferred in the present process such as, for example, perfluorododecyl/perfluorodecyl/perfluorooctyltri-alkoxysilanes, in particular perfluorooctyltriethoxysilane,

and those fluoroalkyl-functional organosilanes which, according to formula I, contain $\text{CF}_3(\text{CF}_2)_7-$, $\text{CF}_3(\text{C}_6\text{H}_4)_6-$, C_6F_5- or $\text{R}^f\text{CH}_2\text{CH}_2(\text{C}=\text{O})-$, where $\text{R}^f = \text{C}_n\text{F}_{2n+1}$ and $n = 2-18$, as the group R^i , for example $\text{F}_{13}\text{C}_6(\text{CH}_2)_3\text{Si}(\text{OC}_2\text{H}_5)_3$. Particularly preferred are

5 tridecafluoro-1,1,2,2-tetrahydrooctyltrimethoxysilane and tridecafluoro-1,1,2,2-tetrahydrooctyltriethoxysilane and 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluoro-1,1,2,2-tetrahydrodecyltriethoxysilane and mixtures thereof.

Products prepared by the present process are stable and as a rule exist as clear solutions. The compositions of the invention can be diluted with alcohols in any ratio as desired, and can comprise water in amounts of up to 5% by weight.

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The present fluoroalkyl-functional organosiloxanes preferably have a high concentration of silanol functional groups, on the basis of their oligomeric structure, which render them capable, in an outstanding manner, of reaction with substrate surfaces containing hydroxyl groups. Coatings and impregnations with various substrates resulted in

15 excellent oil- and simultaneously water-repellent properties, even after treatment with heat, surfactants and UV, the examples. In appropriate studies on various materials, the present compositions have shown no reduction in efficacy or destabilization even after >6 months.

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The compositions of the invention or prepared by the present process are used with significant advantages over the products of the prior art. Using the composition of the invention, at the same time a hydrophobizing, oleophobizing

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Having generally described this invention, a further understanding can be obtained by reference to certain specific examples which are provided herein for purposes of illustration only and are not intended to be limiting unless otherwise specified.

Example 1:

A 10 g amount of H₂O (0.56 mol) is mixed with 5 g of HCOOH (pure: 0.11 mol) in a 250 ml glass beaker at room temperature, while stirring, and 160 g of ethanol (3.5 mol) are then added, and a pH of about 3.5-4 being established. Thereafter, 10 g of VPS 8261 (3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1,1,2,2-tetrahydrooctyltriethoxysilane) are added dropwise (0.02 mol) and the mixture is subsequently stirred for 5 hours with no further change in pH. Thereafter, the material balance is established at a total weight of 1000 g with 915 g of ethanol (19.9 mol).

A clear, colorless solution which has a content of 1.0% by weight of VPS 8261 and a storage stability of at least 6 months is obtained.

Comparison Example:

The procedure is as described in Example 1, but HCOOH is replaced by 1 molar HCl (pH \leq 1). A milky cloud thus formed after 48-72 hours, and thereafter a significant phase separation takes place within 2 weeks. After this period, the composition appears only slightly cloudy, but with a translucent, waxy layer which settles on the base and walls of

containers of both glass and plastic.

Example 2:

5 A 10 g amount of H₂O (0.56 mol) is mixed with 4.0 g of
CH₃COOH (pure: 0.09 mol) in a 250 ml glass beaker at room
temperature, while stirring, and 2.0 g (pure: 0.03 mol) of
isobutylamine is added, a pH of 4.5-5 being established.
Thereafter, the material balance is established with 50 g of
ethanol (1.1 mol). A 5 g amount of
10 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluoro-1,1,2,2-
tetrahydrodecyltriethoxysilane) is added dropwise (0.008 mol)
and the mixture is subsequently stirred for 5 hours with no
further change in pH. Thereafter, the material balance is
established at a total weight of 500 g with 429 g of ethanol
15 (94.4 mol).

A clear, colorless solution which has a content of 1.0%
by weight of 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-
heptadecafluoro-1,1,2,2-tetrahydrodecyltriethoxysilane and a
storage stability of at least 6 months is obtained.

Example 3:

20 A 25 g amount of H₂O (1.4 mol) is mixed with 5 g of HCOOH
(pure: 0.11 mol) in a 250 ml glass beaker at room temperature,
while stirring, 10 g of DYNASYLAN® 1203 (3-
25 aminopropyltriethoxysilane) are added dropwise (0.07 mol) and
50 g of ethanol (1.1 mol) are then added. A pH of about 8.0
is established. Thereafter, 5 g of VPS 8261
(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1,1,2,2-

tetrahydrooctyltriethoxysilane) (0.01 mol) are added dropwise and the mixture is subsequently stirred for 5 hours (no further change in pH). Thereafter, the material balance is established at a total weight of 750 g with 655 g of ethanol (8.8 mol).

A clear, colorless solution which has a content of 0.67% by weight of VPS 8261 and a storage stability of at least 4 months is obtained.

Example 4:

A 15 g amount of DYNASYLAN® 1203 (3-aminopropyltriethoxysilane) (0.045 mol) is mixed with 5 g of VPS 8261 (3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1,1,2,2-tetrahydrooctyltriethoxysilane) (0.07 mol) and 50 g of ethanol (1.1 mol) in a 250 ml glass beaker at room temperature. Thereafter, 25 g of H₂O are added with continued stirring. A pH of about 9-10 is established. The mixture is subsequently stirred for a further 5 hours (no further change in pH) and the material balance is established at a total weight of 500 g with 405 g of ethanol (8.8 mol).

A clear, colorless solution which has a content of 1.0% by weight of VPS 8261 and a storage stability of at least 4 months is obtained.

Example 5:

Using the solutions of Examples 1-4, coatings were produced on glass sheets, steel sheets, aluminum foils, copper sheets, cardboard, paper and polyester and impregnations were

produced on cellulose, wood. leather and cotton.

In order to treat these materials, the substrate specimens were immersed in the ready-to-use solutions of Examples 1-4 for about 5 minutes and, after removal, the solvents were removed at 120°C in a drying cabinet over a period of about 30 minutes.

Thereafter, the substrate specimens showed significant hydro- and oleophobic properties. These characteristics are demonstrated, inter alia, by the following properties:

Beading effect of heating oil, silicone oil, water, contact angle > 100°, "anti-graffiti", "anti-soiling", "anti-fouling". Even after storage of the formulations for several months at room temperature, with varying moisture contents and under the influence of daylight, substrates treated with the formulations exhibit these favorable characteristics.

The disclosure of German priority Application No. 196 49 954.2 filed December 3, 1996 is hereby incorporated by reference into the application.

Obviously numerous modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.